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THE ANATOMY OF A DOUBLE CALF.

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THE subject of this article is a Durham calf born near Minneapolis, Minn., in March, 1901. It lived only ten minutes; but excepting that there was a fracture in the hip bone no indication of injury was seen, and the different organs presented such a healthy appearance as to justify the belief that the calf could have been reared by taking special pains to that end. I owe the opportunity to examine the case to Mr. H. W. Howling, a taxidermist of Minneapolis, who sent me the carcass after the removal of the skin. I am indebted to Dr. C. Hart Merriam, Washington, D.C., for an introduction to the literature of teratology.

The appearance of the stuffed skin is shown in the two photographs, Figs. 1 and 2, views from behind and from the dorsal surface. There are two perfect anterior bodies, each with its head and thorax and the anterior part of the abdomen, and there are four perfect anterior limbs. The left body appears in the mounted condition (see Fig. 2) to be a complete body, into the side of which the anterior right half has been grafted at an angle of about ninety degrees. The hind legs stand nearly at

right angles with the axis of the left half, while they are nearly in the plane of the axis of the right. The internal structure, however, as will be seen, shows that in reality there are two nearly complete bodies strangely united to form the animal. Posteriorly the two bodies are united to form a single region, standing on a right and left hind leg, each of which belongs to one of the anterior halves of the body. There is a third hind leg. It does not touch the ground, but arises from the center

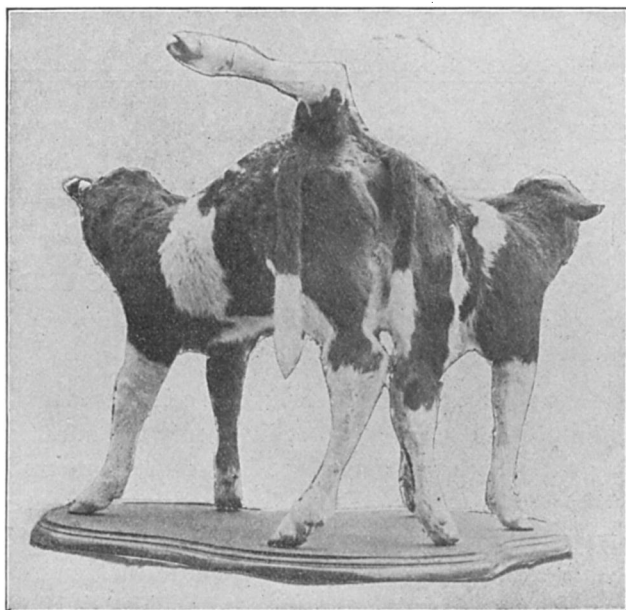


FIG. 1. — View of stuffed skin from behind, from a photograph.

of the rump and projects backward and to the left. This leg has the usual form and regions. Of course I have no means of knowing its bony structure, but it shows the same external subdivisions as the others and ends in two hoofs; the limb, however, is shorter than the others, as shown in this table of measurements.

	LEG.	FORE LEG.	FOOT.	HOOF.
Right hind leg	11 in.	8 in.	3 in.	1½ in.
Middle hind leg	6 in.	6 in.	3 in.	1½ in.

There are two tails, of the same form and size. They are symmetrical in position, each located between the functional hind leg of its own side and the middle leg. The anus is single; it is located directly under the median hind limb and equally distant from the tails. No indication of a urogenital opening was seen, and the structure of the bladder indicates that the penis had not been formed.

The coloration of the skin exhibits noticeable bilateral symmetry; the general ground color is brown, on which white spots,

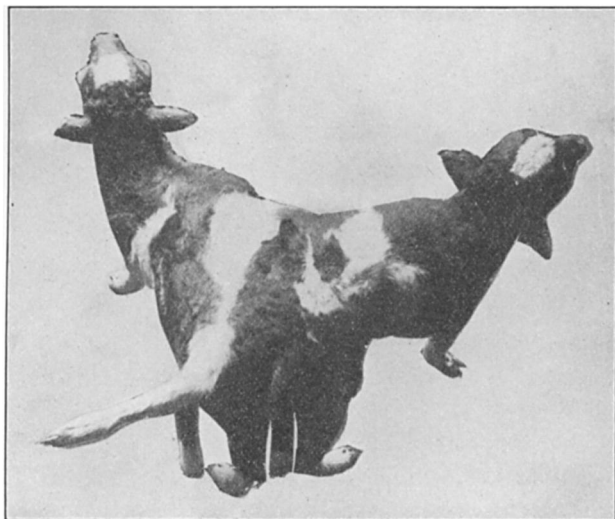


FIG. 2. — View of dorsal surface, from a photograph.

or areas, are found closely matching each other as to position and shape. On the top of each head is a white spot of much the same position, size, and shape; the two tails end in white, of the same length in each. The limbs are white below, except the inner fore limbs, both of which are brown to the carpal region, and the right to the toe in addition. A girdle of white encircles the body of each; it is more solid on the left side. There is a patch on the loin region of each. The following measurements were made from the mounted animal:

Height of body at hip . . .	27 in.	Length of right tail	13 in.
Base of tail to tip of right nose	35 in.	“ left “	13 in.
“ “ “ left “	35 in.		

The body as it reached my hand had the skin removed, and the heads and lower limbs. The external points noticed were these: There was a single anus; a single median umbilical opening was present; there were two bilaterally placed testes located on the wall; they had passed to the surface but no scrotum was formed; they were somewhat widely apart (four inches?); a penis was not present. There are two complete spinal columns, as would be inferred from the presence of two

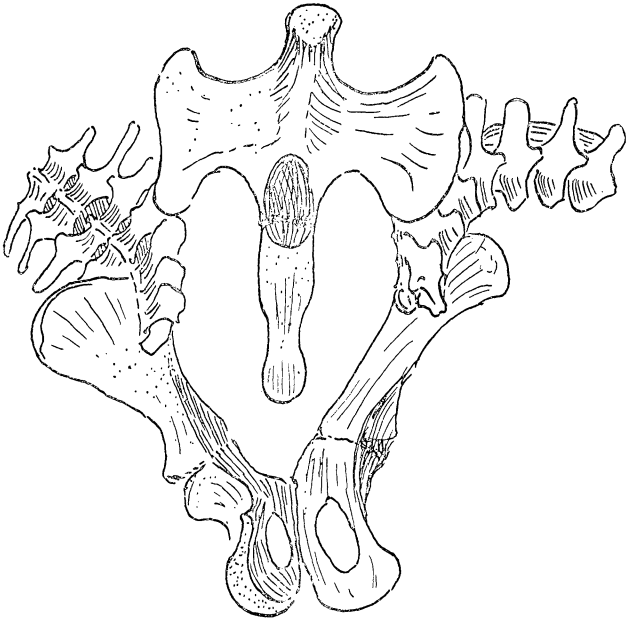


FIG. 3. — Dorsal aspect of the bones of the sacral region.

tails. They are, however, both considerably modified in and behind the lumbar region, as shown in Figs. 3 and 4, which are dorsal and ventral views of the osteological preparation of that region. Both columns are evidently present; they come toward each other and then bend into parallelism, the right becoming concave on the right side, and the left on the left side. This is brought about by the outside of each vertebra being considerably smaller than the inside. The transverse processes of the lumbar vertebræ are not much more than half as large on the outside of the vertebra as they are on the opposite

side. The sacral vertebræ are not only bent as described but there is a twist in them so that the centra come to face inwards, and instead of looking downward they look toward each other. Each sacrum articulates on its outer side with an os innominatum of the usual form, consisting of ilium ischium and pubis, meeting to participate in the formation of an acetabulum for the reception of the femur of the paired leg of its own side of the body. The pubic bones meet ventrally and form a normal

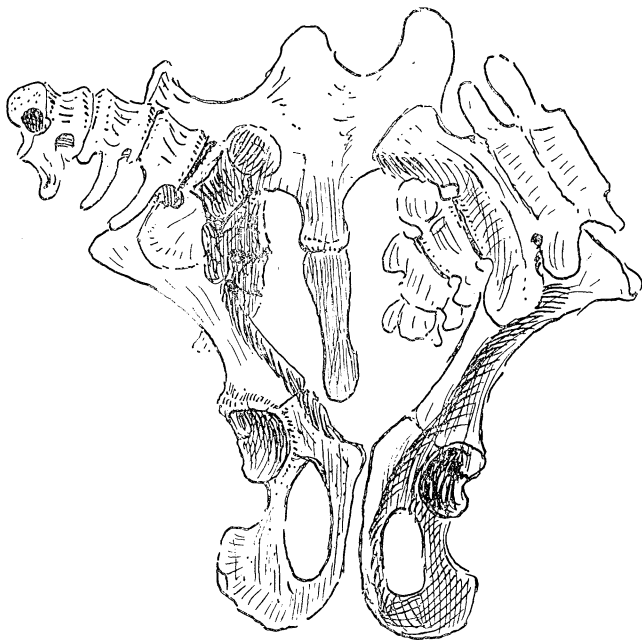


FIG. 4. — Ventral aspect of the bones of the sacral region.

symphysis pubis. The two sacra articulate internally with a peculiar bone, evidently composed of two incomplete ilia. This bone presents anteriorly two crests, each with the usual relation to the corresponding sacrum. In the center of this median bone there is a ridge which ends bluntly in front, and posteriorly meets a broad, thin, and somewhat tapering bone by a distinct suture. At the junction of these two parts is situated a shallow but distinct articular surface; it is the acetabulum of the median hind leg. It is very evident that the anterior bone

is composed of parts of two ilia incompletely separated, and that the hinder bone is in like manner made up of the parts of two still less developed ischia, while no traces of the pubes have appeared.

No dissections of the muscular or nervous systems were made, but we can infer from the osteology that there were two complete spinal cords. The innervation of each of the two functional hind legs must have been from the spinal cord of its own side. This separateness of the cord would have seriously affected coördination. It is related that in the two-headed turtle locomotion was very imperfect (Barbour, '96), and in Ritta-Christina (Hektoen and Riesman, '01) a pinch on the right leg was felt only by Ritta and one on the left only by Christina. The indications from a study of the bones are that the musculature of the outer legs was complete, while the muscles and nerves of the inner side must have been partly, though very incompletely, developed.

The viscera of the thorax were not examined. This is to be regretted, because it would have been important to determine whether the two hearts and vascular systems were counterparts. It seems likely from the anatomy of the animal, so far as known, that they were; still, I am unable to assert the fact. There were two complete diaphragms, and the abdominal cavity was

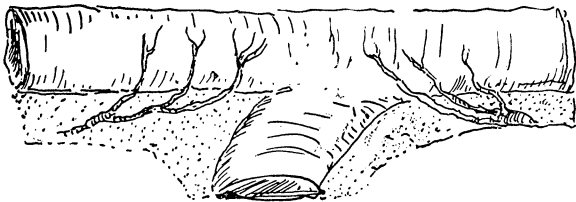


FIG. 5. — Junction of the small intestines of the two anterior bodies, and origin of the single posterior small intestine.

completely subdivided anteriorly. The two livers were entirely distinct, as were also the two stomachs and the upper parts of the intestines. The small intestines run toward each other and meet, forming a continuous tube, as is shown in Fig. 5. There is no indication of a union of two parts at this junction. The vascular supplies of each part are totally distinct, the vessels of

each side running out to reach the common territory. The distance from this junction to the anus is seven feet and two inches, in all of which the intestine is single. The single small intestine arises obliquely out of the common passage, and not, as might be expected, squarely from it. After running a distance of three feet, the small intestine dilates to form the large intestine. Here two cæca of unequal size are located. The two cæca are exactly opposite each other, and their cavities are continuous. At their junction they open together into the intestine at the beginning of the large intestine. The large intestine runs directly to the single anus, a distance of four feet and two inches.

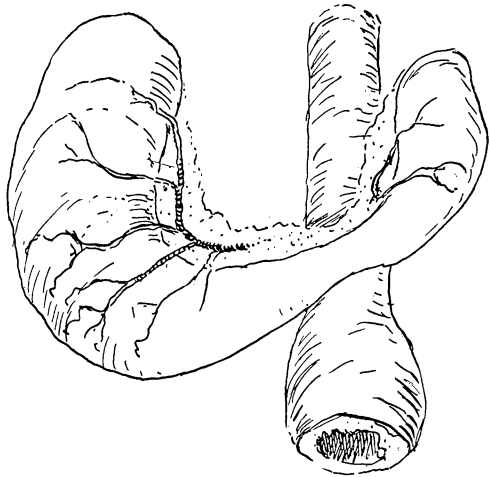


FIG. 6.—The two cæca at the junction of the small and large intestines.

There is normally in the calf only a single cæcum. The presence of two, then, is due to contributions being present from each of the component bodies of the animal. The single intestine could be interpreted in either of two ways, *vis.*, that there was a single intestine into which that of the other half had been engrafted not far from the stomachs, or that the intestine is really parts of two fused in the middle line and thus forming one. The oblique insertion of the single intestine at its origin seems at first to favor the first view, but there is considerable evidence against it. Dr. Wyman ('66), in the case of a double human embryo which he dissected, found that the intestines meet in the middle line and fuse to form a single tube, which, however, soon parts, forming two which run side by side for a time, after which they unite in a single rectum and terminate in a single anus. The presence of the two cæca in the case before us indicates that parts of two intestines, each

running the entire length of the half body to which it belongs, meet in the middle line to form one tube. This mode of origin is in harmony with that seen in the inner iliac and ischial bones and the median hind leg.

The vascular system shows a similar arrangement. Anteriorly there are two complete systems, while posteriorly the systems are complete on the outside, but not entirely so in the central

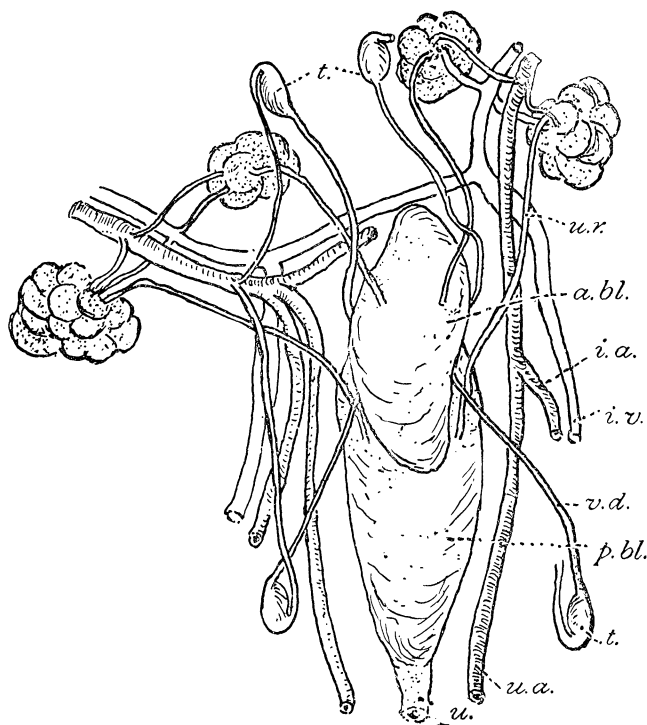


FIG. 7.—The urogenital organs and related blood vessels: *a.bl.*, anterior bladder; *p.bl.*, posterior bladder; *u.*, urachus; *ur.*, ureter; *u.a.*, umbilical artery; *i.a.*, iliac artery; *i.v.*, iliac vein; *t.*, testis; *v.d.*, vas deferens.

area. There are two dorsal aortæ (Fig. 7), and the renal and spermatic arteries are in pairs on both sides, as if the bodies were independent. Posteriorly, however, the aortæ each give rise to one large iliac artery to go to the paired leg of that side, and a second which was not traced beyond the root, where it soon disappeared among the muscles. At the fork of these iliacs a single umbilical artery arises from each aorta; it runs

down alongside of the bladder and, passing out with the urachus, runs to the placenta. A second umbilical artery for each would be needed to complete two entire bodies; these are wholly wanting. There are two posterior venæ cavæ, one for each body half, and similar renal veins were recognized. Posteriorly

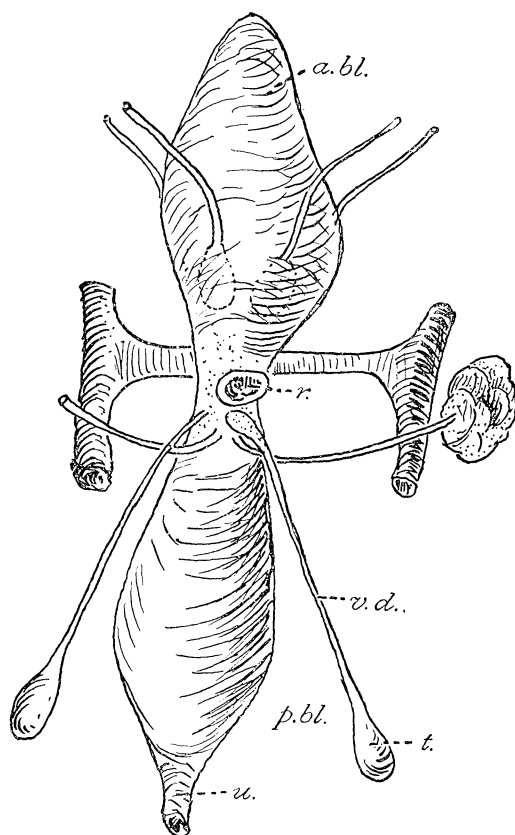


FIG. 8.—The two bladders and related ducts. The anterior bladder has been folded over forward so as to show the anterior surface of the posterior bladder: *r.*, rectum; the other letters as in Fig. 7.

the venæ cavæ divide and give rise, after the manner of the aorta, to an iliac vein for each of the two paired hind legs. But the inner iliac veins run toward each other and meet and fuse, forming a single large communicating iliac vein, thus extending the list of posterior parts common to the two body halves.

There are four complete and independent kidneys; two, by their position and vascular relations, are clearly indicated as belonging to each component body. The kidneys are compound, after the form general in ruminants; each has its hilus looking toward the dorsal aorta, at which three vessels enter its substance, *viz.*, the renal artery, the renal vein, and the ureter. There are two bladders; both are median in position, and one is located in front of the other. They may be designated as the anterior and posterior bladders. They both spring from a common neck, where they are attached indirectly, in common with the end of the rectum, to the body wall. At this place they partly surround the end of the rectum. They are in open communication at the neck by a passage running on the right side of the rectum; but in this region, where the urethra should appear, none is present, and there is no communication here with the exterior. No indications of a penis were found. The posterior bladder had an open urachus whereby it could discharge, but the anterior lacked this entirely, and drained through the passage at the neck into the posterior bladder. The relations of these two bladders is such that the posterior bladder receives the ureters from the two outer kidneys, while the anterior bladder receives those of the inner pair. The ureters of the posterior bladder run down and open into its anterior or dorsal surface, as shown in Fig. 8, and in doing this are aberrant, it being the opposite side to that general in mammals. The anterior pair of ureters are similarly aberrant. Two views are possible with reference to these bladders: either they may be considered as belonging one to each of the two component bodies, in which case we should be obliged to consider that they had, unlike most of the organs of the compound, taken a non-homologous and unsymmetrical position; or else they may be regarded as a single formation common to the two bodies, comparable with the hinder part of the intestine, which has been secondarily subdivided. The latter view seems perhaps more in harmony with the rest of the construction of the body, but decisive evidence cannot be had from the materials furnished in the dissection.

The genital organs show the same relations as the renal system. There are four testes: two are related to the two kidneys of one body and the other two to those of the other. These four testes are, however, paired in the calf not with reference to their individual bodies, but with reference to the compound. Two, as already mentioned, have descended: they are the right of the right body and the left of the left; we may call them the two outer testes. The two inner testes also carry out the symmetry, both remaining in their primitive position beside the kidney. These testes all reach the exterior by means of ducts which have the same relation as do those of the corresponding kidney. Those of the outer testes cross the ureters from the outer kidneys and enter a glandular mass (seminal vesicles?) in the wall of the posterior bladder. The two inner vasa deferentia run down and attach to the anterior bladder, passing as normally to the posterior surface.

The entire urogenital system thus follows the same law of symmetry of the homologous parts as we have seen in the other systems of the animal. This is the more interesting in this case, for in regulating the relations of the ducts from the organs the law comes into conflict with the symmetries of the two individuals and replaces it. This is evidence of the presence of a deeper law of regulation, and indicates the "fission theory" (Hektoen and Riesman, '01) of origin for the monster rather than the "union theory."

The limits of this article do not permit an extensive notice of the literature of teratology; a list of writers consulted is given at the close. Dr. Fisher ('66) gives a figure of a calf much like this one externally,—a case of "*diplocephalus tetrabrachius tripus*,"—but the supplementary hind foot is ventral and anterior, indicating a difference in the mode of union of the pelvic bones. No account of the anatomy is given. He mentions that it was dissected by Dr. Wyman, but I have not been able to get any information of that dissection or its results. The case belongs in the line of double formations, which begins at the minimum with doubling of digits, runs through every stage of double formation of hands, arms, and other parts, of whole regions (as the head and trunk),

and finally culminates in twins: either incompletely separated, as the Siamese twins, or completely separated as in ordinary cases. Authorities in the main assign all such cases to a "division of the ovum imperfectly effected," so that "the resulting bodies instead of becoming complete twins remain united together, frequently having a greater or less extent of the body in common"; thus Bateson ('94): "Double formations arise from a fission of the whole or a part of the original embryonic mass." There are two theories as to the process: "one holds that they arise by splitting of the original germinal area of one embryo, and the other that they arise from the fusion more or less of two distinct embryonic areas lying in one ovum" (Hektoen and Riesman, '01, p. 419 *et seq.*). The present case indicates a partial fission of the germinal material, that destined to give rise to the anterior parts being wholly divided, while some of that destined for some of the hinder organs remains undivided. This case comes between the Tocci brothers and the Siamese twins. The former of these I have seen, and Fig. 9 is from a photograph of them. In these the hinder part of the body is apparently strictly single; there is less division than in the calf specimen. The Siamese twins were essentially double throughout. In the calf the hind part of the body is incompletely double. There are cases very nearly like it, of which a brief mention will be interesting. The Hungarian sisters, Helen and Judith, had one vertebral column as far forward as the second sacral vertebra; there was a single anus and rectum; both felt the same desire to defecate; there was a single vulva but separate urogenital systems; they urinated separately by different urethra; menstruation came at different periods in each (Hektoen and Riesman, p. 430).

In the case of Ritta-Christina the following items are noted from the account in Gould and Pyle ('97, p. 185): umbilical cord and placenta single; heads, necks, arms, and thorax above double; abdomen single; lungs imperfectly double, the central lungs being underdeveloped; one pericardium but two hearts; hearts synchronous; digestive organs separate as far as lower third of ileum, then single to the anus; stomachs, spleen, etc., were right and left; livers right and left were

fused centrally; there were two gall bladders beside each other in the middle line; the uterus was double; the vertebral columns were entire and separated by a mass of bone consisting of fused rudimentary ossa innominata; the sterna were united at their manubria. Reference has been made in an earlier part of this paper to the case of a human fetus dissected by Dr. Jeffries Wyman ('66). It was less double than the calf. There were only three arms, the median one made up of two halves fused; a single pericardium enclosing two hearts; a single lower vena cava branching anteriorly to enter each heart; the umbilical cord had one vein and two arteries. The right and left duodenums came together a short distance from the two stomachs, whose pyloric

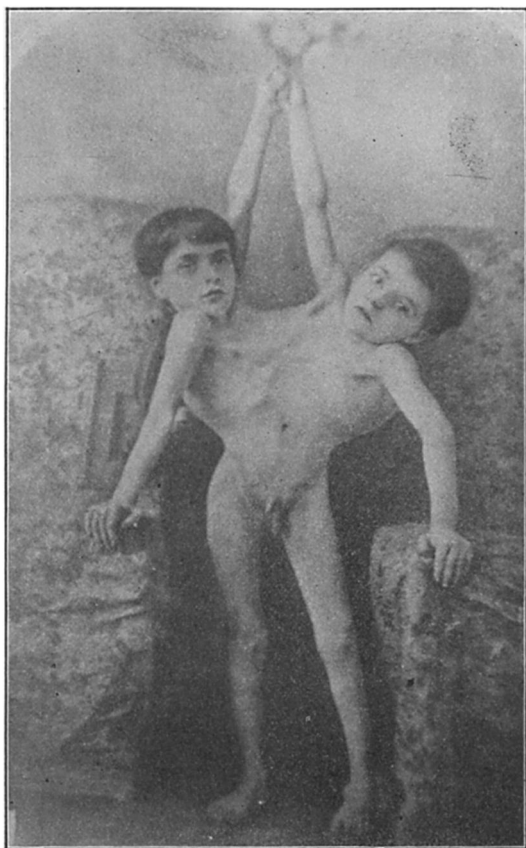


FIG. 9. — The Tocci brothers, from a photograph in possession of the writer.

ends were turned toward each other ("symmetrical counterparts," Bateson, p. 559), but afterward separated and, though side by side, continued distinct nearly to the cæcum, which, as well as the large intestine, was single. There was a single urinary bladder with a double cavity. There were only two kidneys, but they were compound, and each had two ureters,

one set opening into the upper bladder and a second, much larger, opening into the lower bladder. The bladders had the usual shape, but inwardly the mucous membrane formed a partial partition, near which the two sets of ureters opened. There were also two pairs of testes, one of which were resting on or quite near the kidneys and the other had descended and were "just at the entrance of the inner abdominal ring."¹ This case is much like that of the calf,—the union of the two intestines, the four ureters, and the two bladders, one in front of the other; it is not clear that the outer pair opened into the hinder bladder, but that seems to be intended. The account of the anatomy of the kidneys leaves somewhat to be desired; apparently the fission of the embryonic material had not gone so far here as in the calf specimen as to the kidneys, while it had as to the ducts. The relation of the testes and the ducts seems to have been about the same as in the calf.

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SAINT PAUL, MINN., April 2, 1902.

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¹ Partly quoted and partly condensed from Wyman's paper.